Northwestern University Department of Physics and Astronomy

PHYSICS 411-0 CLASSICAL MECHANICS

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Course Webpage: `http://www.hep.anl.gov/ian/teaching/CM/CM_Winter10.html`

ASSIGNMENT #1

Due at 2 PM, January 13th

Reading Assignments:
Chapters 1 and 2 except Sections 2.4 and 2.5 of Goldstein's book.

Problem 1
Given the Lagrangian of a free particle in an inertial frame $L_0 = mv^2/2$, consider two inertial frames K and K' moving with the constant relative velocity $\mathbf{V}$. Derive the transformation property of L_0 under the Galilean transformation:

$$\begin{aligned} \mathbf{r}' &= \mathbf{r} + \mathbf{V}t \\ t &= t' \end{aligned}$$

and show the equations of motion are the same in the two frames. In other words, the Lagrangian of a free particle satisfies the Galileo's relativity principle.

Problem 2
Next we consider the Lagrangian of a free particle in an accelerating frame K', moving with respect to an inertial frame K with a non-constant velocity $\mathbf{V}(t)$. Notice only the magnitude, but not the direction, of $\mathbf{V}$ is time-dependent.
(a) Show the Lagrangian L_0' in K' is given by

$$L_0' = \frac{1}{2}mv'^2 - m\mathbf{W}(t)\cdot\mathbf{r}' \ ,$$

where $\mathbf{W} = d\mathbf{V}(t)/dt$.
(b) What is the Euler-Lagrange equation for L_0'? Derive the equation of motion in K' and give a physical interpretation of your result.

Problem 3
Problem 2.4 in Goldstein's.

Problem 4
Problem 2.12 in Goldstein's.

Problem 5
Problem 2.24 in Goldstein's.